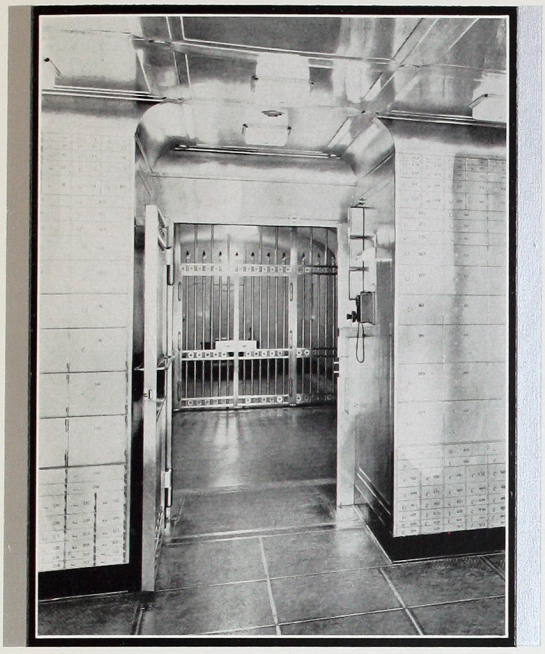


ENDURO

K A 2

Manufactured under Krupp-Nirosta patents

THE remarkable properties of the stainless irons have resulted in a development almost without parallel in metallurgical history. There are few industries that have not shown the imprint of these alloys in better products, in reduced costs or in increased production.

Up to the present time, straight iron chromium alloys have had the greatest application, but demands for an even better product have resulted in the introduction of an alloy free from the somewhat unsatisfactory qualities shown by the straight chromium stainless irons under certain conditions. This has been accomplished by the addition of a considerable proportion of nickel to the regular stainless analysis.

Alloys of this type were first developed by Dr. Benno Strauss, of the Krupp Works, Essen, Germany. They have been extensively used in Germany since their introduction, particularly the well-known alloy V2A, but until recently have attracted little or no attention in this country. Today their valuable properties are beginning to be realized and they are rapidly supplanting the straight chromium iron alloys in many applications.

The addition of nickel — a metal possessing in itself considerable corrosion resistance — to the stainless analysis greatly increases the corrosion resistance of the alloy, extending this resistance to a number of materials which attack stainless iron, to the point of complete immunity from attack. The addition of nickel also increases resistance to scaling at high

temperatures, reduces grain growth, and at the same time prevents embrittlement after long service. Metallurgically, the effect of nickel is to produce an alloy of the stable austenitic type: characterized by extraordinary toughness and ductility, no capacity for hardening by heat treatment, high resistance to impact, and the property of being non-magnetic.

The mere addition of nickel to the stainless analysis in itself will not produce maximum corrosion resistance. The full advantage of the addition is not obtained until the alloy has been properly processed according to the specifications originated by Dr. Strauss. Republic Steel Corporation, being a licensee under the Krupp-Nirosta Patents, offers this alloy, properly processed, under the trade name of Enduro KA2. It is thus the American equivalent of V2A alloy of Krupp.

ENDURO K-A-2

Typical Analysis

Carbon	under .16%
Chromium	16.5–20.0%
Nickel	7.0–10.0%
Silicon	under .75%
Manganese	under .50%
Sulphur	under .030%
Phosphorus	under .030%

Weight—virtually the same as steel—0.2833 lb. per cubic inch.

Thermal Conductivity approximately 40% that of .40 Carbon Steel.

Resistance to High Temperature Scaling

Continuous Service 1650°F.

Intermittent Service 1450°F.

Coefficient of Linear Expansion — Temperature	x10^{-6}
0– 100°C. =	16.0
0– 300°C. =	17.0
0– 600°C. =	18.0
0–1000°C. =	20.0

Melting Point (approximately 2560°F.)

AVERAGE PHYSICAL PROPERTIES KRUPP PROCESS HEAT TREATED 24 GAUGE SHEET

Ultimate Strength	90,000 lbs. per sq. in.
Yield Point	45,000 lbs. per sq. in.
Elongation in 2″	55.0%
Elongation in 4″	50.0%
Elongation in 8″	45.0%
Rockwell B	80.0
Olsen Cup Test	.450–.500

(Lighter gauges will have lower cup values)

AVERAGE PHYSICAL PROPERTIES KRUPP PROCESS HEAT TREATED ROUND BAR STOCK UP TO 2″ RD.

Ultimate Strength	85,000 lbs. per sq. in.
Yield Point	40,000 lbs. per sq. in.
Elongation in 2″	55.0%
Red. Area	65.0%
Rockwell B	80
Brinell	156

(Larger sizes will have lower strength values)

The work hardening characteristics of Enduro KA2 permit a considerable increase in tensile strength and raising of the yield point by cold working operations. The ductility is lowered considerably by such treatment.

It is not uncommon to find 250,000 lbs. tensile strength, 2% elongation and 40-45 Rockwell "C" hardness in cold drawn KA2 wire.

Cold rolled strip having 180,000 lbs. ultimate strength, with 5 to 10% elongation in 2″, can be obtained. It will stand a 180° bend across the grain of the metal and 120° to 180° with the grain.

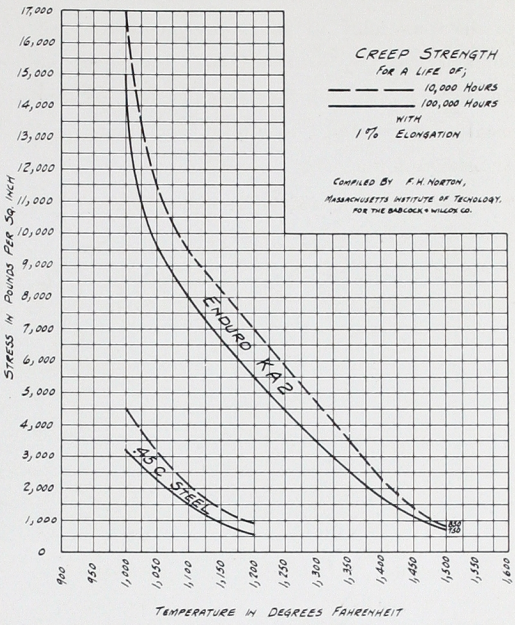
Physical properties of high temperatures

ENDURO KA2 because of its high chromium content together with the nickel possesses very good "Creep Strength." The alloy does not become embrittled in service and for this reason finds extensive application in oil refineries. The "Creep Test" curves (right) may be used in obtaining strength values for designing high temperature equipment.

Forging, Flanging, etc.—Heat slowly to about 1500°F., then rapidly to 1900°F.-2200°F., which is the proper forging temperature. If forging is not completed when the piece has cooled to about 1700°F. it should be reheated, as the metal will be cold worked if forged below this temperature. Caution is given against working this alloy between 1300°F. and 1800°F. as within this range the alloy is somewhat red short as indicated by a lowered elongation and reduction of area and for this reason flanging must be done below or above these temperatures. Enduro KA2, having greater strength and hardness at high temperatures, will of necessity be somewhat stiffer than other metals and will require more blows under the hammer to accomplish the same reduction.

Annealing—To secure the best service from Enduro KA2, it is essential that it should be used in the heat treated (annealed) condition. The metal then has greatest resistance to corrosion and is also most ductile, and hence best suited for bending, forming, deep drawing, etc. For this reason all Enduro KA2 is given the special processing necessary during the course of manufacture at the mills.

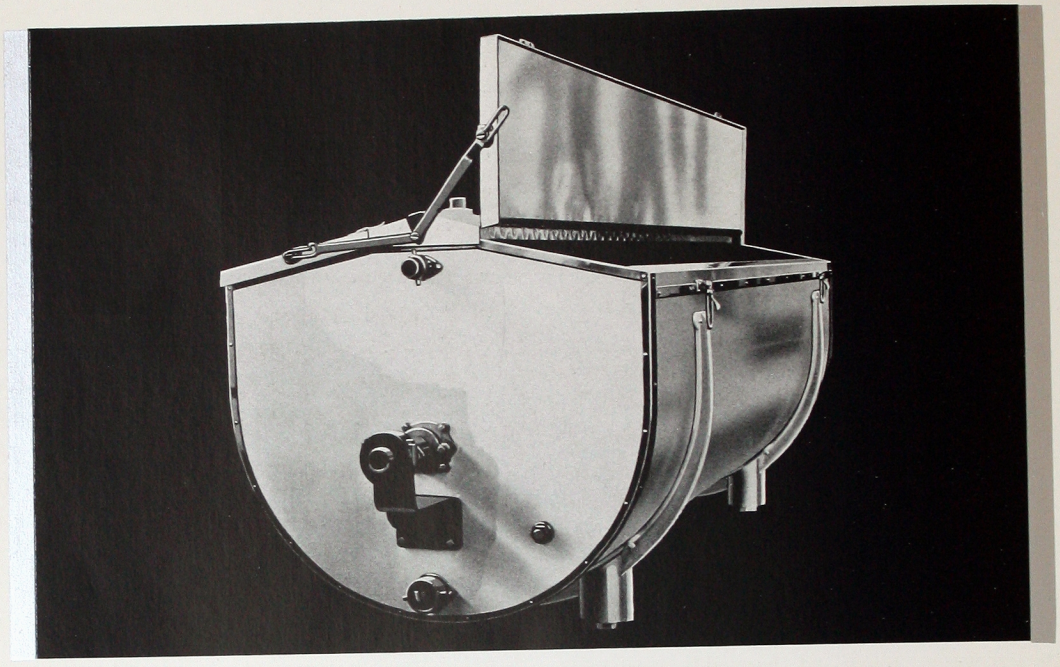
If in the fabrication of units intended for severe wet corrosion conditions, the alloy is cold worked to considerable extent, the piece should be annealed by heating rapidly to within the temperature range 1950°-2100°F. and cooling rapidly. Such treatment



Instructions for working Enduro K·A·2

will insure the maximum drawing qualities and resistance to corrosion.

In contrast to ordinary iron and steel, Enduro KA2 *must be cooled quickly* from the annealing temperature, either by quenching in water, if sections are large, or in air, if small. If in drawing or forming operations the metal becomes hardened because of cold working, and further softening is necessary for subsequent drawing, the above treatment should be used rather than an anneal with slow cooling as is customary with plain carbon steel. When only a very small amount of further reduction is required or it is desired to relieve only cold working strains it is possible to put the alloy in condition by annealing at a somewhat lower temperature. It is advisable that articles which have been drawn and require annealing have the lubricating compound removed before treatment, for if it remains on the



Milk Pasteurizer Lined with Enduro K A 2

surface it will cause blistering and may in some cases affect the metal adversely.

Removal of Scale— To remove scale, pickle in a bath of 20% (weight) hydrochloric acid at a temperature between 120°F. and 140°F. Where such acid is not available a solution containing about 10% of sulphuric acid and 6 to 12% of rock salt (by weight) should be used hot. The effect of the rock salt is to liberate hydrochloric acid and results in a considerable saving of time compared with a straight sulphuric acid pickle. After pickling rinse thoroughly and dip in a warm solution of nitric acid 15 to 30% (weight) strength and wash in water.

Deep Drawing, Punching and Shearing— Enduro KA2 is excellent material for performing operations of this kind. Its extremely high elongation and low yield point are indicative of what may be expected of this alloy as compared to regular deep drawing steel. It should, however, be pointed out that Enduro KA2 work hardens very rapidly and to a much higher degree than does regular drawing steel. For this reason it is necessary to perform as much work as possible in a single drawing operation and to reanneal between operations.

The blanks used should be of sufficient size as to not require excessive ironing out in the dies to secure cup depth, as the work hardening characteristics of the alloy may cause high breakage loss as well as excessive wear on the dies. The use of a special lubricant of suitable consistency and body is quite important. There are a number of suitable drawing compounds available from chemical supply concerns. Operation of the press should be as slow as possible. Die clearance should be about twice that used for steel or brass.

The work hardening characteristics and high tensile strength of Enduro KA2 make it necessary to use more power in performing drawing operations than

is required in forming and drawing steel of a similar gauge. It is also recommended that a very neat adjustment of shear blades and of clearance between punches and dies be used for punching and shearing. The power required will be greater for the reason previously given and it will be necessary to shear through the entire thickness of metal rather than permit it to snap off after a portion of the cross-section has been cut through, as occurs in punching most materials.

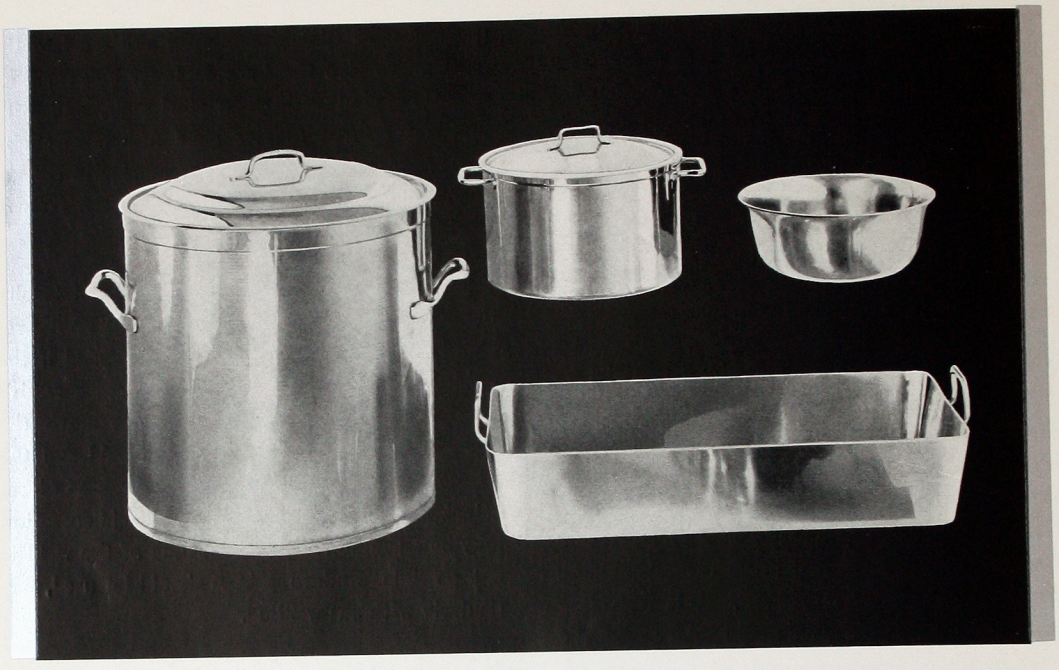
Riveting— Enduro KA2 is the ideal material for rivets. As it does not harden on rapid cooling, nor develop coarse crystalline structure on heating, the accurate temperature control required for straight chromium iron rivets is not necessary. Rivets when driven hot should be heated to within a temperature range of 2100-2200°F. and in no case should the rivets be driven below 1800°F. When riveting smaller size rivets the same may be done cold, the rivet remaining tough and thoroughly dependable.

Welding — Enduro KA2 may be welded by either the acetylene torch or electric arc, using specially prepared Enduro KA2 welding rods. It may also be spot and resistance welded, but cannot be forge or hammer welded. Seam welding of light gauge sheets is readily accomplished. Having no capacity for hardening, welds remain tough and ductile and do not develop the coarse, crystalline structure characteristic of the straight chromium iron alloys.

For acetylene welding, uncoated welding rods should be used. With plates and other heavy materials, chamfer the edges to be welded and place these a small distance apart. Build up a bead between these edges, keeping the flame pointed in the direction of welding so as to preheat the work. Use a slightly reducing flame, and see that it is no larger than necessary for the work to be done.

For electric arc welding, special coated rods must be used. Reverse polarity (electrode must be positive and work the negative pole) and regulate the machine to give the same or lower voltage than would be used with plain steel rods, and with sufficient current to give good fusion. Definite instructions cannot be given as much will depend upon the character of the work and the type of machine used.

While welds made with Enduro KA2 are naturally tough and ductile, the annealing treatment previously mentioned is strongly recommended if the welded material is to withstand severe corrosive attack. This treatment will tend to remove the difference in structure between the weld and the adjacent metal, which is the primary cause of local attack in welded structures. Where acid corrosion may be encountered and annealing of the weld is not possible, Enduro KA2-S should be used, particularly with gas welding.



Enduro K A 2 Restaurant Equipment

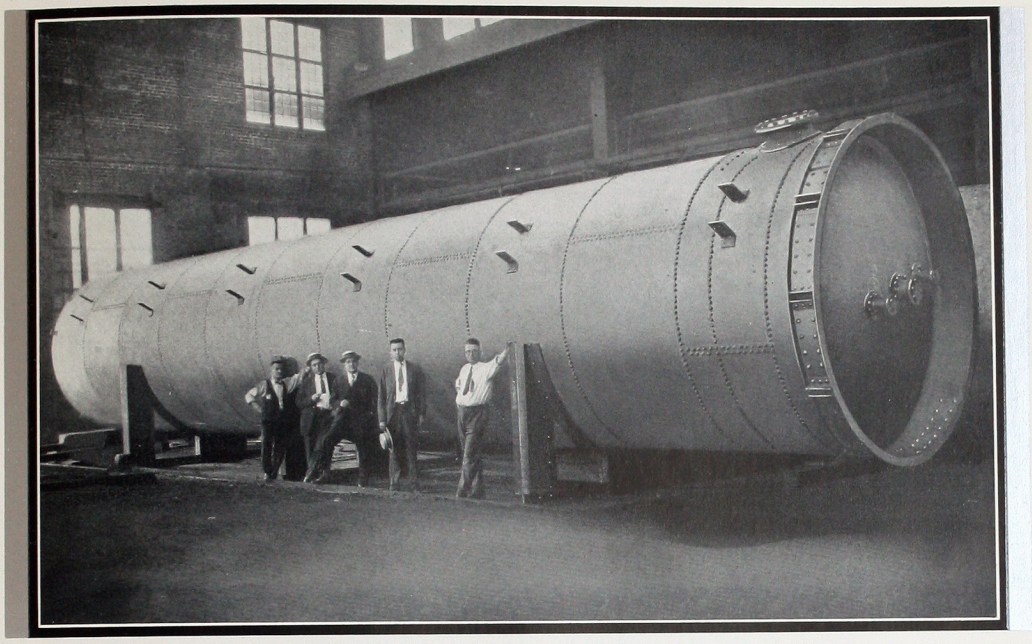
Soldering — Enduro KA2 may be soldered without difficulty, firm, strong joints being produced. For pickled finish sheets, the ordinary muriatic acid cut with zinc may be used. For polished sheets, if there is difficulty in making the solder adhere, the surface may be dulled with the following solution:

Muriatic Acid (HCl)	90 Parts
Ferric Chloride ($FeCl_3$)	50 Parts
Nitric Acid (HNO_3)	3 Parts

The solution should be allowed to act for five to ten minutes, or longer, if necessary, then wiped off. Tinning is then to be done in the usual way. If difficulty is still encountered, an acid solution similar to the above, but which has been cut with zinc, should be used. After soldering, *all traces of acid must be thoroughly removed* by washing with soap and water to which has been added some bicarbonate of soda, as the acid attacks the metal readily and will stain if not removed. On account of the low thermal conductivity, use a large soldering iron which will have sufficient heat capacity to heat the metal thoroughly. The metal comprising the joints should be properly tinned before assembly. The half-tin, half-lead type of solder is quite satisfactory. Lock seam and lock seam riveted joints are preferable. Rivets should be tinned before driving which of course is done cold.

Brazing — We would recommend welding rather than brazing whenever possible due to the excellent welding properties of KA2 and to the possibility of intercrystalline penetration of the brazing alloy which lowers corrosion resistance under wet corrosive conditions by favoring electrolytic action. Brazing must be carefully done to prevent the penetration of brazing alloy into the grain boundaries of the metal.

For brazing, proceed in the usual manner, observing the precaution of having the metal thoroughly hot. If difficulty is encountered in making a firm joint,



Riveted Nitric Acid Tower of Enduro

the metal should be tinned by the process previously given before brazing.

A satisfactory flux for brazing may be made by mixing four parts of borax with one part of ferric chloride by weight, in a solution of zinc chloride made by dissolving zinc in muriatic acid, to form a thick paste, and applying a small quantity of this to the parts to be brazed before heating. Then proceed with ordinary brazing material.

Machining, Sawing and Drilling — Being an austenitic alloy, Enduro KA2 is tough and somewhat difficult to machine. Best results are obtained with slow cutting speeds and moderately heavy cuts. Tools must be ground and kept sharp, and with a steep side and lip rake (at least 15 degrees). In threading, arrange so that four or five teeth engage, instead of the usual two or three. A long soaking period in a temperature range of from 1200-1500°F. will in some cases be of assistance where considerable machining is necessary. If this treatment is followed and maximum corrosion resistance is desired, it is necessary to reanneal at a minimum of 1950°F. after rough machining is completed.

Drilling should be done with a high speed drill, and best results are obtained when the drill is ground somewhat flatter than is customary. The drill should cut all the time, and in laying out work as small a mark as possible is advisable, as the punch will work harden the alloy and make it difficult to start the drill. The use of a backing material such as cast iron to conduct away the heat will be of assistance. Immersing the drill in water after each hole is drilled will increase the life of the drill. The speed of the drill should be about one half that used in the case of mild steel. When drilling deep holes or hollow boring a compound made up of one pound of sulphur to one gallon of lard oil will prove of value.

In sawing, a high speed blade should be used of the fine tooth, wavy type. When possible it is preferred that a circular type saw be used.

ENDURO

TYPE K A 2 S

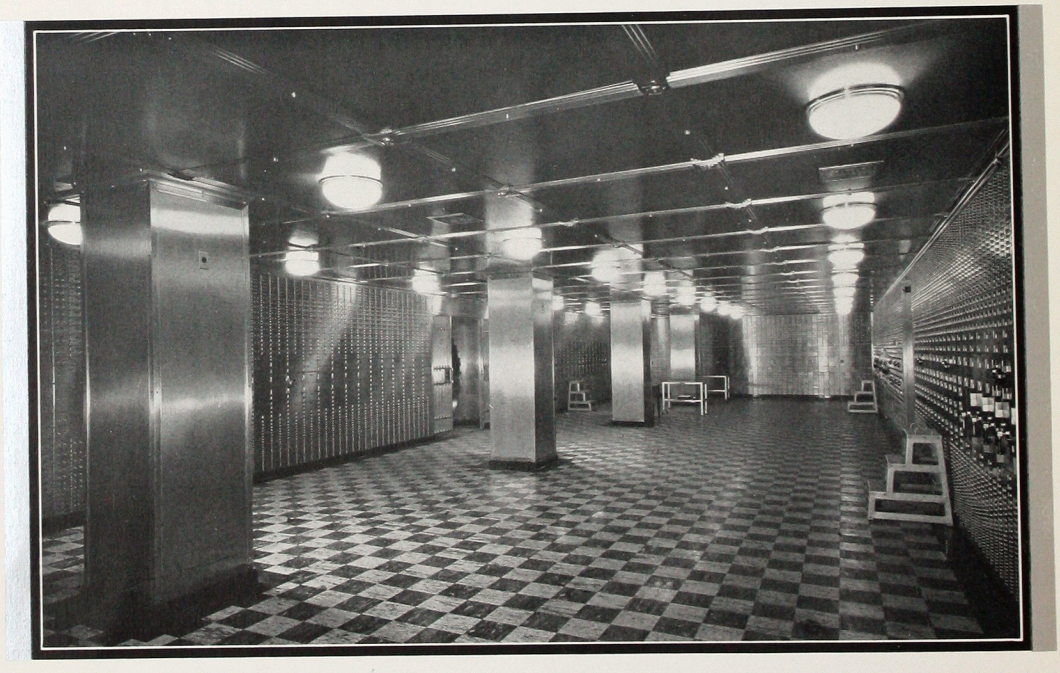
TO MEET the needs of the oil refining and other industries requiring an alloy for high temperature service in combination with high pressures, Republic Steel Corporation has further improved and developed Type KA2 into this new type (KA2-S). The alloy is primarily intended for use within the temperature range 1000 - 1350°F., and for welded construction where acid corrosion is encountered.

Analysis

Carbon	under .07
Chromium	16.5–20.0%
Nickel	7.0–10.0%
Silicon	under .75%
Manganese	under .50%
Sulphur	under .030%
Phosphorus	under .030%

The general properties of this alloy are identical with those of Type KA2. The information given for Type KA2 is applicable to Type KA2-S.

REPUBLIC STEEL CORPORATION :-: YOUNGSTOWN, OHIO



Enduro in Bank Vault Construction

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